HOW MUCH DO WE KNOW ABOUT WHAT OUR STUDENTS KNOW OF STATISTICS?

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Owing to the shortage of didactic preparation which teachers possess after their academic formation, the novices are obliged to learn at a very quick pace the functioning of the dynamic school. With so much novelty, evaluation stands out in the broad sense and also as the receiver of all information. In this paper we examine the method of work by means of an example, in projects of statistical education and their evaluation through a trainee portfolio analysing the information obtained and using it as a source to regulate the inter-action in the classroom. This will help us to appreciate the grade of knowledge acquired by the students in certain concepts of statistics proposed in the Spanish curriculum for students from 15-16 years in obligatory secondary education.

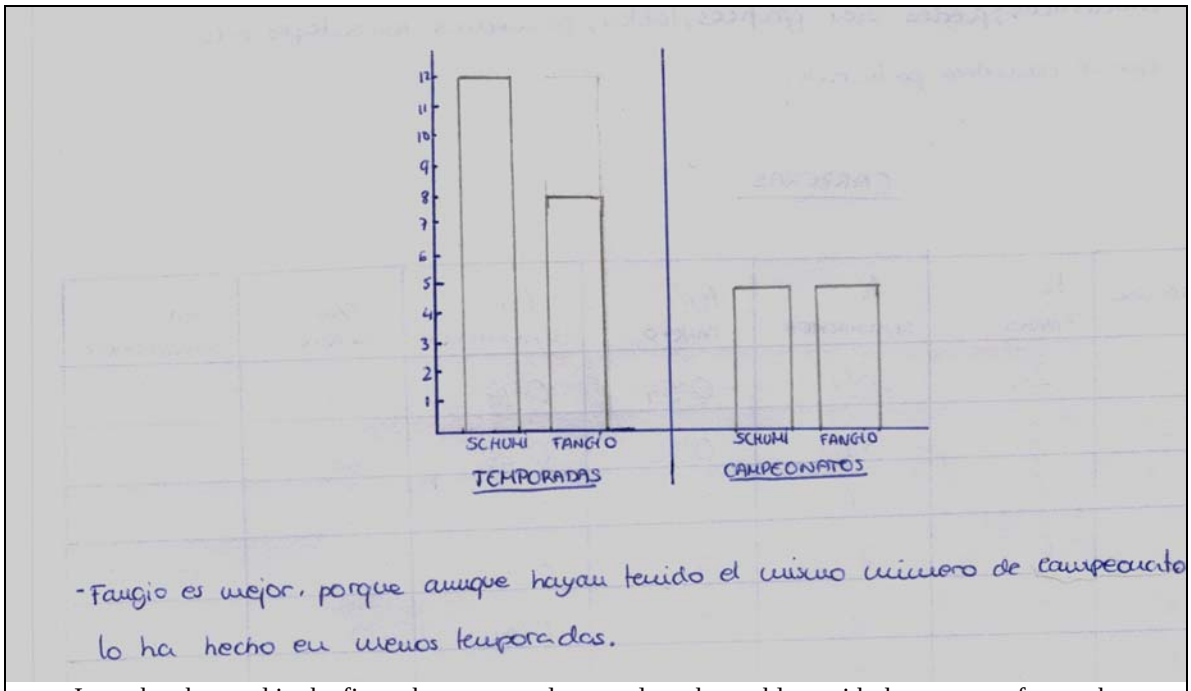
WORK IN PROJECTS, SOURCE OF MOTIVATION.

After some previous experiences put forward by Vega (2005) and Vega and Cardeñoso (2005) we decided to concentrate on work in projects as an alternative method to the traditional with the intention of being as close as possible to the daily reality of the students, to achieve more and better involvement by them in their own education (Batanero & Diaz, 2004).

In this way, the method used is composed of activities which the students should face individually in some cases and in small groups in others where the discussed concepts are reaffirmed with master classes and training exercises and finishing with a small project done in pairs (Oliveras, 1996) and debated in a large group, together with an individual written control.

Following the sequenced planification of teaching by Vega, Parrales and Cardeñoso (2006) the activities were divided into four categories:

Motivation activity: The activity called *Formula 1* (Ávila, 2005) was used not only for motivating the students but also for detecting previous ideas conceived by them. This offered a general vision of the skills they possessed (OCDE, 2004) in addition to being a different way of confronting the data of a mathematical text, asking for an interpretation and not only a numerical solution.



It can be observed in the figure how one student resolves the problem with the support of a graph.

Intuition activities: Consisting of answering three series of ten phrases in which the students, using logic and intuition, should decide with which amount of centralisation the data of said series could be best represented.

Consolidation activities: Consisting of a collection of training activities with specific procedures.

Final project: Since it was the first time that many students used the trainee portfolio (Serradó, Cardeñoso & Azcárate, 2003) and worked with projects; the final projects were not very open and set out so the students could know clearly what they were facing at every moment.

DIVERSITY OF ACTIVITIES, SOURCE OF INFORMATION

The law which regulates the educational system proposes a summary and formative evaluation, so teachers could be able to determine how much the cognitive structure of their students has evolved. But how can we achieve such information having only one examination to determine the students' skills at the end of each subject? In the traditional system the evaluation is relegated to a mere qualification; however, our objective is to answer one of the principal functions of the evaluation: to regulate the process of knowledge acquirement.

Therefore, the trainee portfolio is used as a fundamental instrument for the evaluation of the project (Garfield, 1995).

Owing to the immaturity of the students, a directional portfolio (Shulman, 1999) was used so that the student would know what to do at each moment, even though the activities in it were more open and could be confronted in different ways and depth.

Below are the activities included in the portfolio which were used in order to obtain the maximum information possible.

Formula 1: This activity was chosen to detect previous knowledge and skills possessed by students and having a high level of motivation since it is a very popular followed sport in Spain.

It consists of a text written in colloquial language that contains information related to two car pilots, Schumacher and Fangio. The students must analyse and present the information in the most suitable way to answer some questions aimed to determine which pilot has been the best one in the history of Formula 1.

With this activity, we were trying to discover which were the statistical abilities possessed by the students at the same time seeing the way in which they confronted the exercises and which required a non numerical "solution".

Mean, medium and mode: A list of sentences were given to the students, so they must decide which measure of central tendency could describe better characterize the situation. We realised that the majority of students had difficulty in differentiating when it was better to use one measure or another.

For this reason, it was decided to provide a second list of sentences in which they should decide not only which measure of central tendency was appropriate but also the reason for their choice.

The third set of data was proposed so that apart from doing what was asked in the previous activities, the students must invent a relative problem in which solution they should use the measure of central tendency by argument previously mentioned above.

So what do we know about statistics: This was the name given to our project which consisted in seven exercises of differing nature/subjects, in which the students should confront in pairs and trying to do a synthesis to close the presented subject and examine whether the students had integrated the new concepts to their mental structure before the final written exam in which the procedures acquired were evaluated.

The kind of tasks within the project consisted in several exercises, two of them could be denominated theoretical in which the students should be clear about certain concepts and definitions to make some connections between them; one in which they had to interpret a histogram of frequencies below the only question *What does the following graph tell us?;* two new ones in which they should analyse the suitability of a sample taken so that the study gave liable information; another in which they should, according to a shown list of data, decide which was the question of investigation made by who had done the survey, and were asked to represent

the information obtained; and to finish, an exercise in which they should calculate the measures of central tendency of a set of numerical data and decide which of the measures best represented the information of the study and why (Curcio, 1989).

SHARPENING SKILLS

Even when we thought that using a methodology based on projects would improve the motivation and work of the student, we should admit that the students are really accustomed to a much more directed system.

For this reason, it was decided to link both methods of teaching, this allow us to keep the attention of a larger number of students has been achieved than when we used only one of the methodologies.

By means of traditional teaching we have tried to improve the execution of procedures in a better way, as well as using it for closing in a majority, institutionalising the theoretical notions which the students investigated, turning to master classes.

We have also turned to this method to answer the doubts which were presented by the majority of the students trying by means of the formulation of new questions to which they themselves gave answers to their problems. We consider this to be a very powerful tool as in some occasions when a student has a mental block before a piece of knowledge it is easier for him/her to come out of this blockage when a co-student explains the concept or doubt in question with his own words and examples.

ANNALYSIS OF RESULTS

Observing carefully the creations of the students, we have been able to evaluate both in summary and process wise, learning from our own mistakes and at the same time creating the following activities and procure to giving the students the material which they need to reach and grasp the intended skills.

The most relevant observations of the proposed activities are the following:

Formula1: On observation of the tasks given by the students, we prove that the majority knew different systems of representation of statistics, in which stood out the table and histogram of frequencies. Furthermore, some of them using the corresponding notations showed with clarity an educational level in which they were situated as can be seen in the next figure.

CARRERAS

POSICIONES	fi FANGIO	fi SCHUMACHER	fri FANGIO	fri SCHUMACHER	%i FANGIO	%i SCHUMACHER
1º	24	64	0'54	047	54	47
2º	10	34	0'22	0'25	22	25
3º	1	16	0'02	0'11	2	11
4º	6	7	0'13	0'05	13	5
5º	0	6	0	0'04	0	4
6º	0	4	0	0'02	0	2
7º	3	5	0'06	0'03	6	3
	44	136	1'000	1'000	100	100

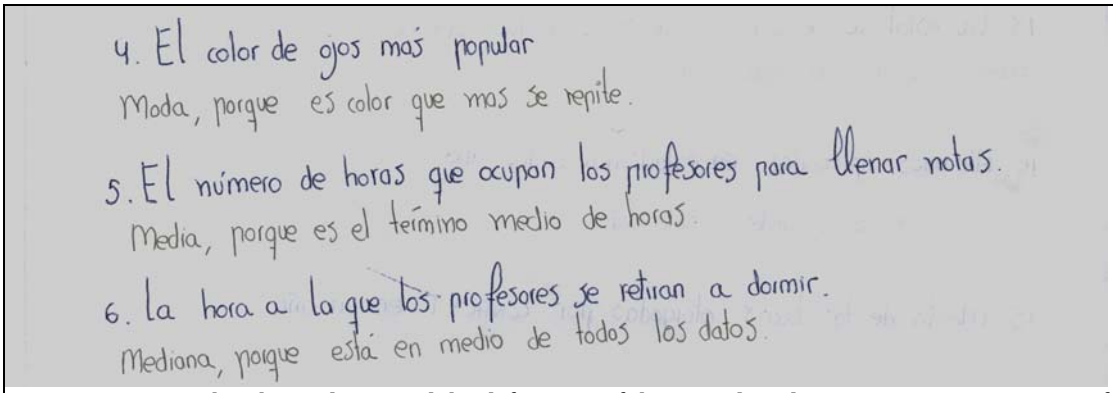
We can check how a student uses the nomenclature and appropriate objects.

It is possible to emphasize that the questions least answered by students and in which those who did had a higher rate of errors, were those in which the students should present the information so that, statistically, it could be observed that one pilot was better than the other.

Asking the students the reason for no answer, some said that they didn't understand how to argue with the same data different positions: first, that the best pilot of all time was Schumacher and then, the opposite, that Fangio was the best one. Other students, shared the doubts with their classmates, but added that they had answered because if the teacher had asked them they should answer, even though they didn't know how to do so.

As consequence, we realised the necessity of the students to be revalued, to believe that their opinion was as equally as important as our own and above the entire realisation that their lives in the mathematics class were not so different to that which they led outside the school. In the case in question, they quickly realised that they acted from day to day in the way asked in the problem emphasising the information that they saw suitable to give more importance to one point of view or another.

Mean, Medium, Mode: They began as a series of propositions offered to the students so that these with which measure of central tendency (mean, medium or mode), it was better to study those assumptions. As we realised they were unable to distinguish in which case one was better than another, we thought that it was because they hadn't dedicated enough time to think which would be the best adjustment, so we decided to give another series as well as the former, in which they had to give the reason for their selection.



We saw that the students used the definitions of the central tendency ranges as an argument for their choice instead of showing their chain of reasoning.

In this new chain the number of errors was less although still high. This fact surprised us because, in the assembly, when we reasoned with them, they arrived at sufficiently coherent conclusions. As a result of this situation, it raised the suggestion of a recurring problem, the students were not used to thinking for themselves and although we understood it could be due to lack of time dedicated at home, we abandoned this idea in favour of the former as we observed that some of the more hard-working students had also fallen into the same error. Other interesting evidence is that the argument they gave for their selection was the definition of the measure of central tendency which they had decided was the most adequate and not their own reasoning. Once again their inability was reflected to repeat mental processes done in class, compared to when they had to do them alone, autonomously.

The third succession appeared to try to get the students, once they had decided which measure was the most suitable, to invent the series for a problem which included the subject of the succession and the data in which they had to calculate the measure that they had thought of. Furthermore, they should resolve and interpret the solution. Finally, we observed that in this last activity the students arrived at conclusions much more coherent than previously.

So what do we know about statistics: When we began to analyse what the students handed in, we realised that the project had been too much directed, as although each pair of students had prepared their own documents, the compositions were all within a very short range.

In these manuscripts we again realised that the students have and put too much stress on theory as in questions like *say what the word "statistics" means to you,* they had looked for the definition in the dictionary or encyclopaedia. Commenting on this fact in class, and even when they admitted that obviously the dictionary didn't say what they as individuals thought was the word "statistics", they finished with phrases like: *"but, isn't that right?* or *I think the same as the dictionary"*.

We had a pleasant surprise when we checked to see if the students had acquired abilities for reading graphs. With the usual method, in the exercises of the kind we find in the text books (Colera, Carcía, Gaztelu, & Oliveira, 2002), we found that the skills they had acquired were in only one sense, given some information we asked them to do a graphical representation of same. In the majority of cases the students did this correctly always when it was indicated for them to do diagrams of sectors, frequency histograms, etc., but they had serious difficulties when they were asked to present the information graphically using the representation that they thought the most suitable.

Apparently, this year, after doing multiple and diverse exercises for reading graphs we have found that on the whole in a written exam about this, there has been a noticeable improvement in the students' comprehensive composition.

Analysing these compositions we have discovered what we suspected: the importance of that the students knew how to analyse critically when a sample was adequate or when the information was contaminated due to acquiring them in a sector of the population who were not objective. For this reason, we worked with the students to make up a list of questions of investigation of the experiment and we saw that on the whole, that in various cases where although the correct question was posed, that contradictory information could still be received in answer if we didn't take a fair sample.

Lastly, comparing work done in the series of activities we called Mean, Medium and Mode bore fruit when we observed that the students were able to analyse information given and suspected that what would result calculating the measure of central tendency. In their vast majority they understood how atypical information could influence the given information and the significance this had on the same.

CONCLUSIONS

Given the cyclical character of the methodology used, supported by a continuous evaluation which evaluates not only the knowledge and processes acquired by the students, but also of the conceptual structure in which it links and the mistakes/difficulties which they have committed, we have been able to delve in a larger way into the notions of the curriculum, not so much in quantity, to which is the normal tendency, as in the quality of the same. Now comparing the obtained results with previous courses in which we observed that the present students, some hardly reaching a level of competence superior to level 3 (OCDE, 2004) carrying out representations of information from a table and giving a simple argument based on the information or using mathematical arguments based on information (level 4), we saw that many had acquired skills of higher levels such as that of inquiries about the aspects of the information from tables and graphs or the use of proportional reasoning and with statistical concepts (level 5), and a few are capable of communicating with complex arguments and explanations employing complex reasoning and using statistical concepts.

All through the portfolio we have confirmed what we have observed in the first examination, that the students are not used to thinking about an activity developed in the classroom of mathematics, but to give answers to problems which do not go with them and of course to think that if there is a question then there should be an answer on their part even though they don't know why, with which the concepts and procedures do not remain structured but in many cases are acts of faith on the part of the students to obtain a positive qualification.

To confront this reality we believe it necessary to plan activities which favour the reasoning taking advantage of the real character of statistics. In practise we have discovered through the activities of Mean, Medium and Mode that with the results obtained, the effort made was well worth while as thanks to this process many of the students passed level 4 (OCDE 2004)

in particular in implementing the text books and facing some of the limitations presented by Serrado, Cardeñoso and Azcárate (2005).

On analysing the global results obtained by the students, we are satisfied that the methodology followed, which has a fundamental base of the participation of the student in the development of specific projects and a continuous evaluation. In this way we have err on those aspects in which the students have shown to have a lack or difficulty, as well as be able to interact with them in a more fluid and dynamic way.

It is affirmed that linguistic abilities are required, knowledge of the context, capacity to put forward questions and a critical posture which is supported by a conjunction of beliefs and attitudes., as suggested by Murray and Gal (2002) in order to get across the comprehension, interpretation and affirmative reaction before the information, training which is stimulated by incentive in work with projects

We believe that owing to the practical character which statistics have, in all the senses, since the information for the exercises can be taken from the closest surroundings and much didactic material exists in daily publications, newspapers, magazines, etc. it is possible to offer our students other options in mathematical teaching in which they see the connection of this with the real world in which they live for which, from there, search to connect the most abstract concepts in their conceptual manner of conduct and so not remain isolated and ready to be forgotten.

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